

# GIS Data Manipulation and Economic Modeling Issues and Examples

Geospatial Statistics and Issues in Energy Modeling Workshop

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# Overview

- GIS Generated Resource Supply Curves
- Uncertainty In Estimating Biomass Spatial Distribution
- Uncertainty In Solar Radiation Estimates Based On Input Data
- Potential Data Sets For Regionalization To Support National Level Models

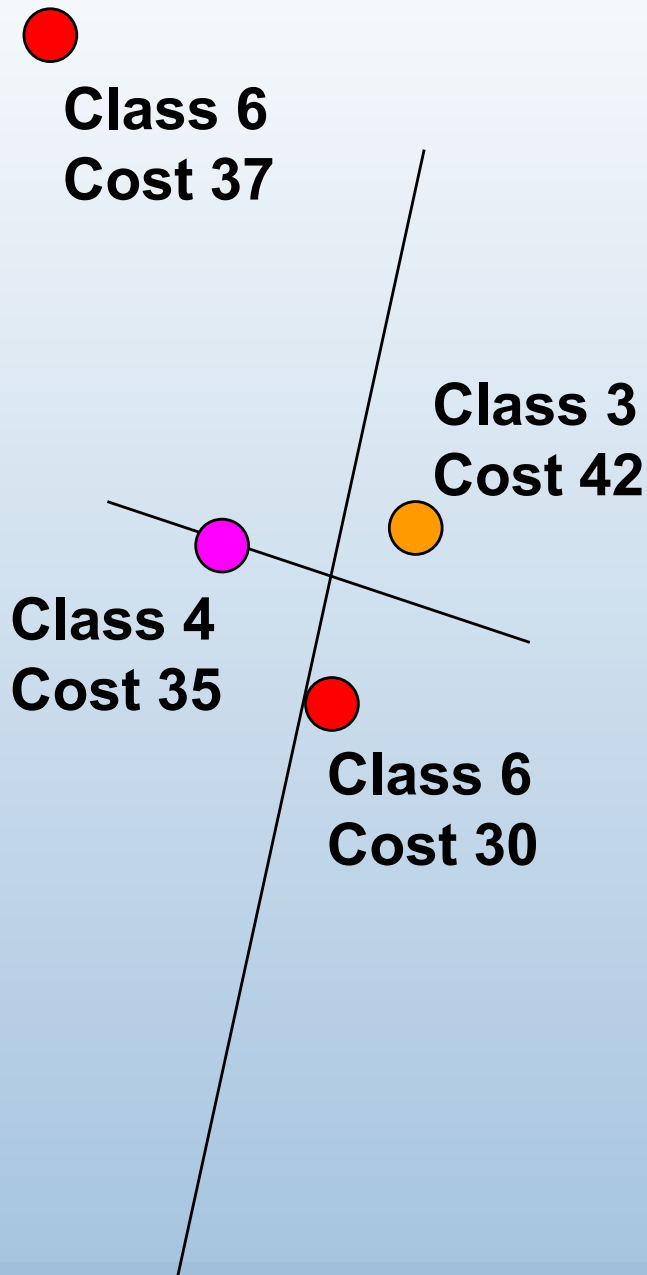
# GIS Generated Resource Supply Curves

- GIS analysis can be used to generate supply curves for regional models
  - Take advantage of higher resolution datasets
  - Account for cost factors with spatial components
    - Transmission line length
    - Slope
- Limited to setting up initial conditions

# WinDS – Regional Supply Curves

- Original wind resource resolution varies from 200 m to 25 km
  - Resource is resampled to 200 m cell size and separated by power class
  - Resource aggregated to 3 km cells
    - Aggregation needed for processing
    - Preserve wind class distribution
    - Cells much smaller than WinDS regions

# Wind to Transmission Line Assignment



- Assign lowest cost wind cells first
- Cost based on:
  - Wind power class
  - Distance to transmission line/load
  - Slope (starting region)
  - Population density (starting region)
- Continues until all wind is assigned or all transmission capacity is used

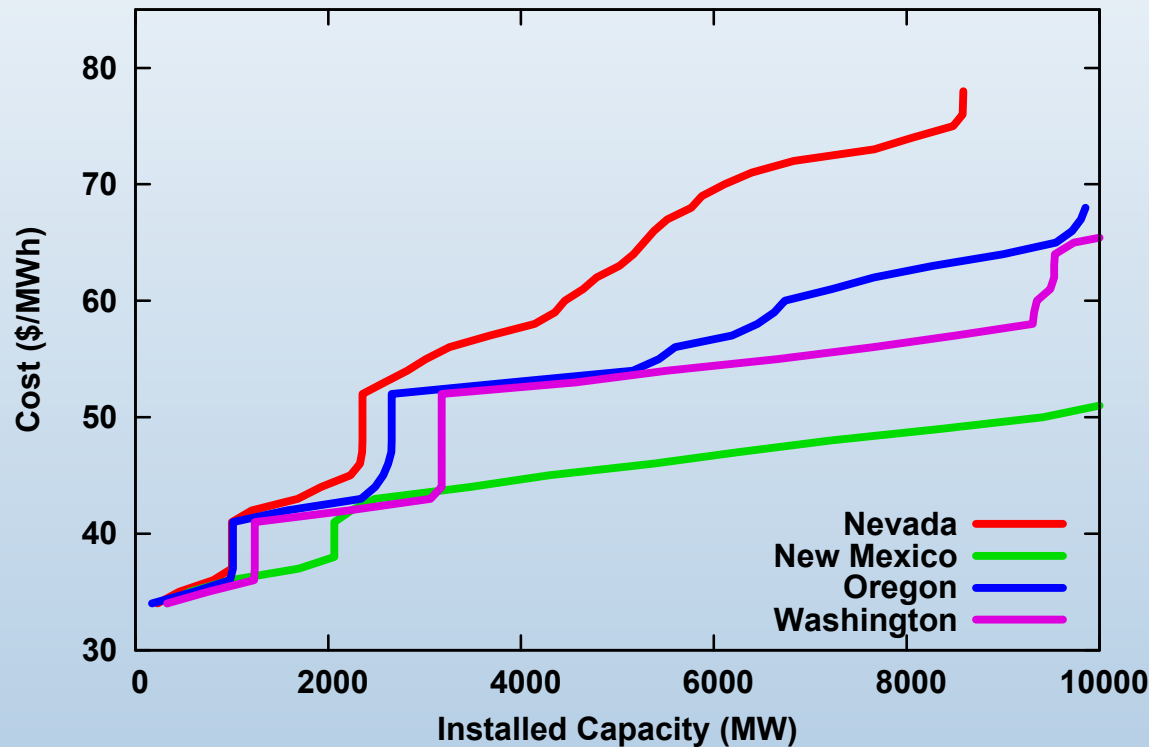
# Generate Regional Supply Curves

Region	WPC	Costbin	Area (km2)
1	7	34	51.3200
1	7	35	37.9600
1	7	36	7.2400
1	7	37	5.4800
1	7	38	2.6000
1	7	39	0.2800
1	7	41	0.8400
1	7	44	0.2000
1	7	45	0.6200
1	6	35	15.8000
1	6	36	19.4400
1	6	37	10.9200
1	6	38	6.9800
1	6	39	9.8600
1	6	40	3.2000
1	6	41	21.9800
1	6	42	30.8400
1	6	43	9.2800
1	6	44	5.2400
1	6	46	8.0000
1	6	48	0.4600
1	6	49	6.0200
1	6	50	18.4800
1	6	51	3.0000
1	6	53	1.8600
1	5	42	10.0800

- GIS system tracks for each resource points:
  - Cost assigned at
  - Amount of area assigned
  - Region the resource is in
  - Transmission line assigned to
- Build supply curves by summarizing resource by power class and cost bin for each source region

# WinDS – Regional Supply Curves

Wind Energy Supply Curve - Western US - Classes 3-7



- Cost factors don't have to be linear
- Assigned cost can be aggregated to other regions (states)
- Can only reflect initial conditions

# How can spatial statistics help?

- What is appropriate starting aggregation size for resource?
  - 3 km picked through trial and error
  - Technology specific factors?
- Load allocation
- Information on spatial correlation of resource
- Predict/extrapolate regional demand growth rates



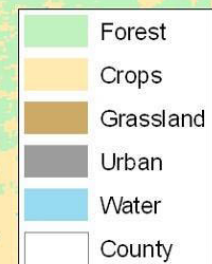
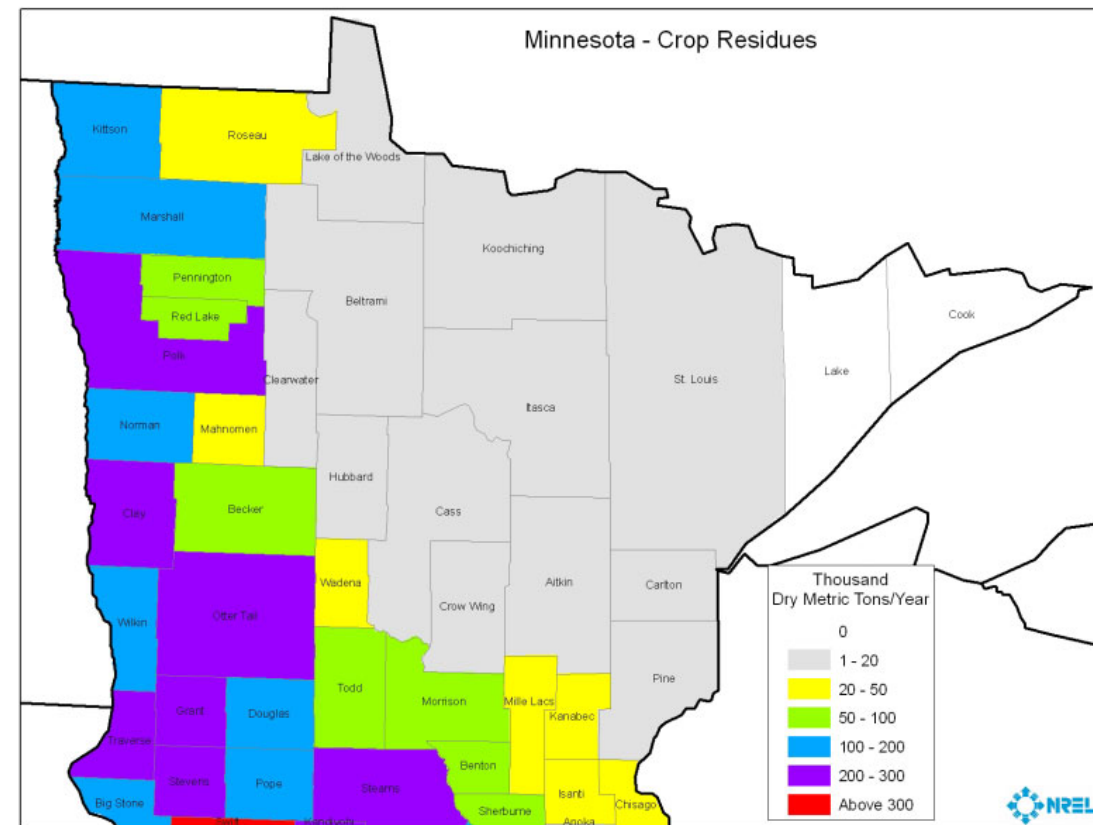
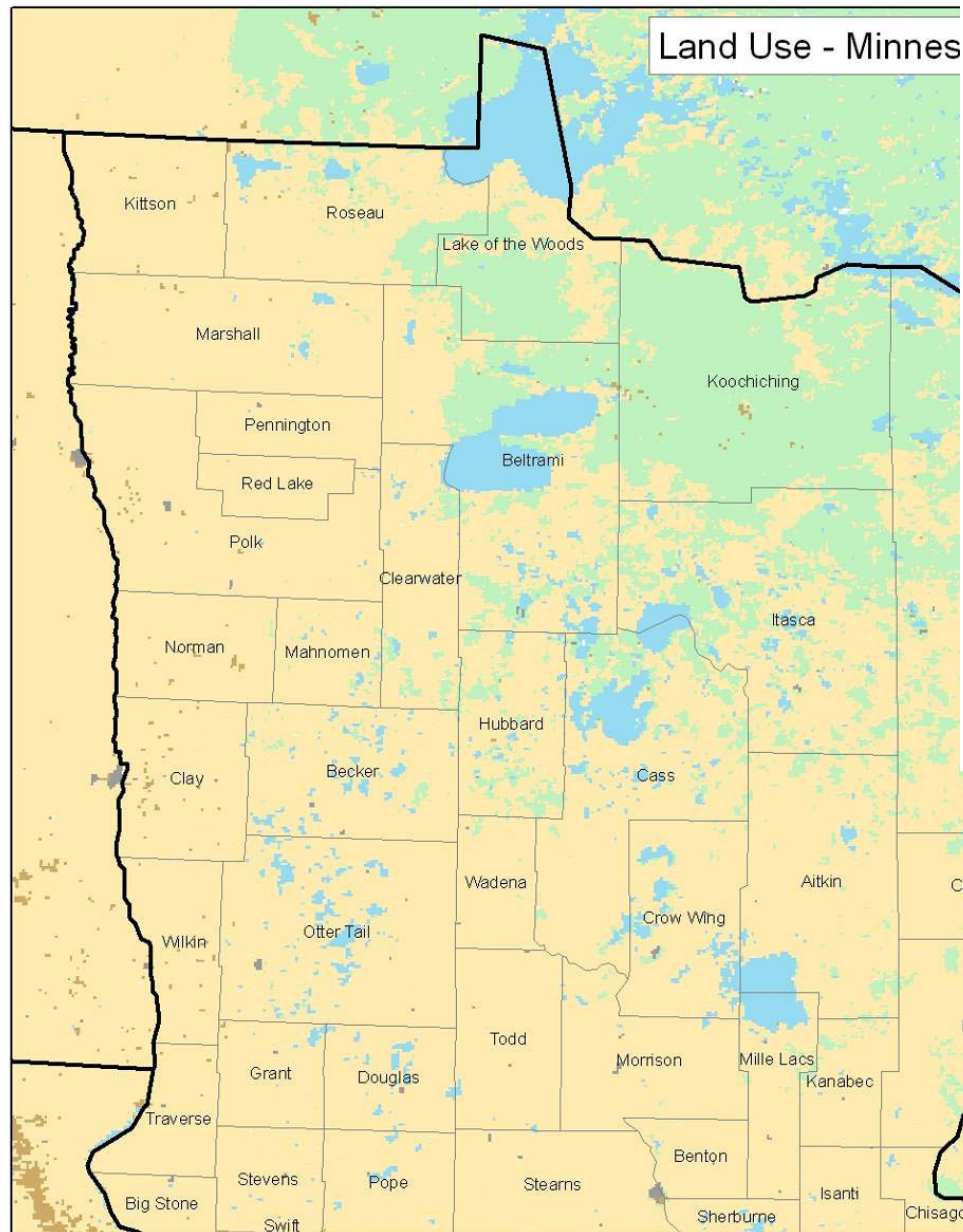


# Uncertainty in Estimating Biomass Spatial Distribution

- Residue data reported by county
- Possible data to support better spatial distribution
  - Land use (crop and forest residues) 1km or better
  - Animal farm locations (animal manure)
  - Mill locations
  - Landfill locations

NREL's biomass assessment is based on statistical data that is reported by county to USDA, Forest Service, EPA

# Differences in Spatial Distribution



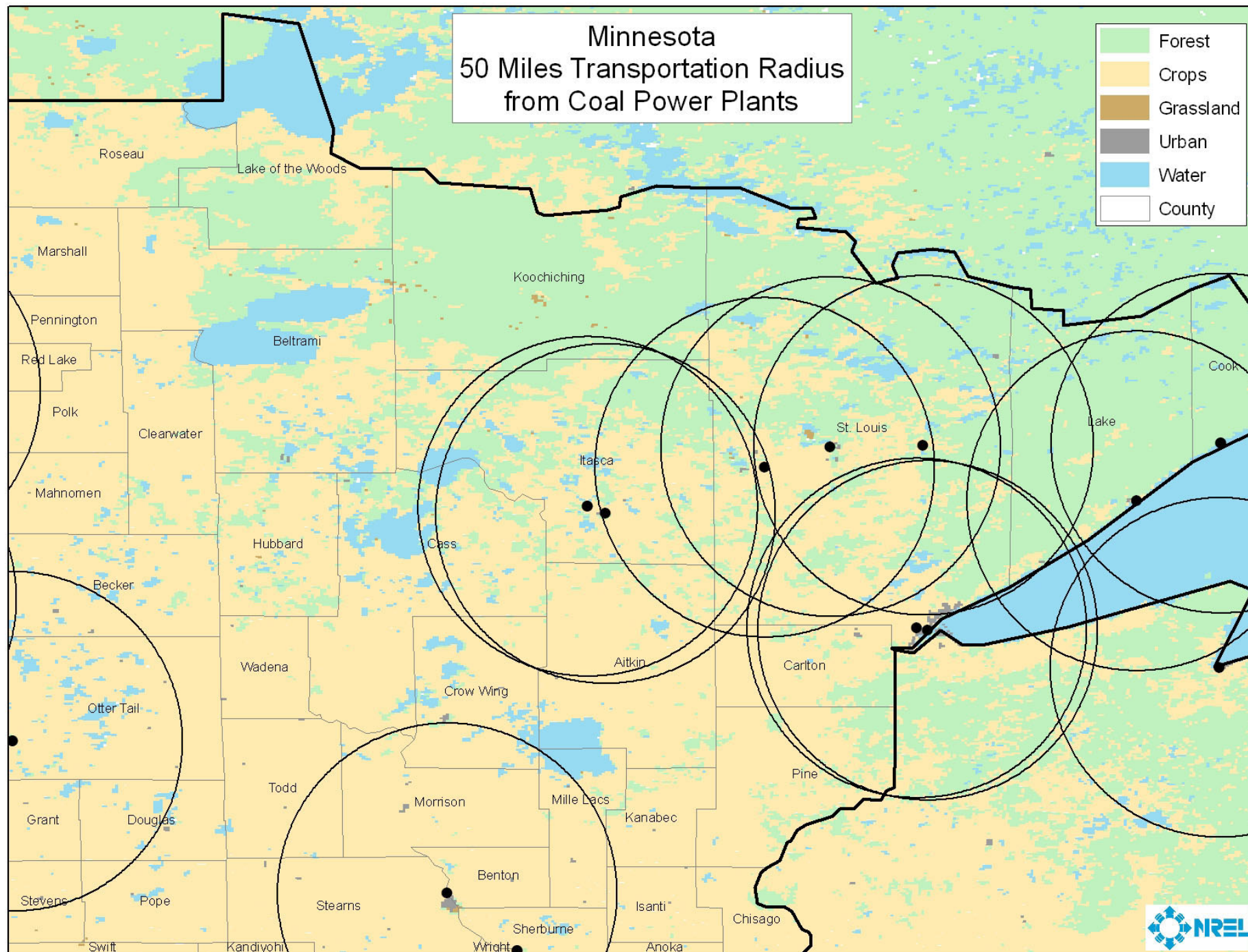
# Importance of spatial distribution of Biomass

- Transportation and transmission proximity for cost analyses
- Building more precise supply curves
- Co-firing with conventional fuels
- Power plant siting

Current by-county distribution forces analysis to use single value or equal distribution



# Minnesota 50 Miles Transportation Radius from Coal Power Plants



# How can Spatial Statistics Help in Biomass?

- Allocate resource to specific areas within a county
- Quantify residue that could be collected within 50, 75, and 100 miles radius from a power plant
- Determine the type of residue that dominates within the radius



# Uncertainty in Solar Radiation Estimates can Directly Influence Success of Concentrating Solar Projects

- Direct Normal Irradiance (DNI) modeled estimates have an uncertainty that ranges up to +/- 20%
- Break-even annual DNI for Concentrating Solar Power (CSP) plants is generally considered to be  $\text{DNI} = 7000 \text{ whr/m}^2/\text{day}$
- DNI values are highly dependent on AOD (Aerosol Optical Depth), which is hard to measure.
- Clean air prospecting with better aerosol data will reduce uncertainty of DNI estimates.

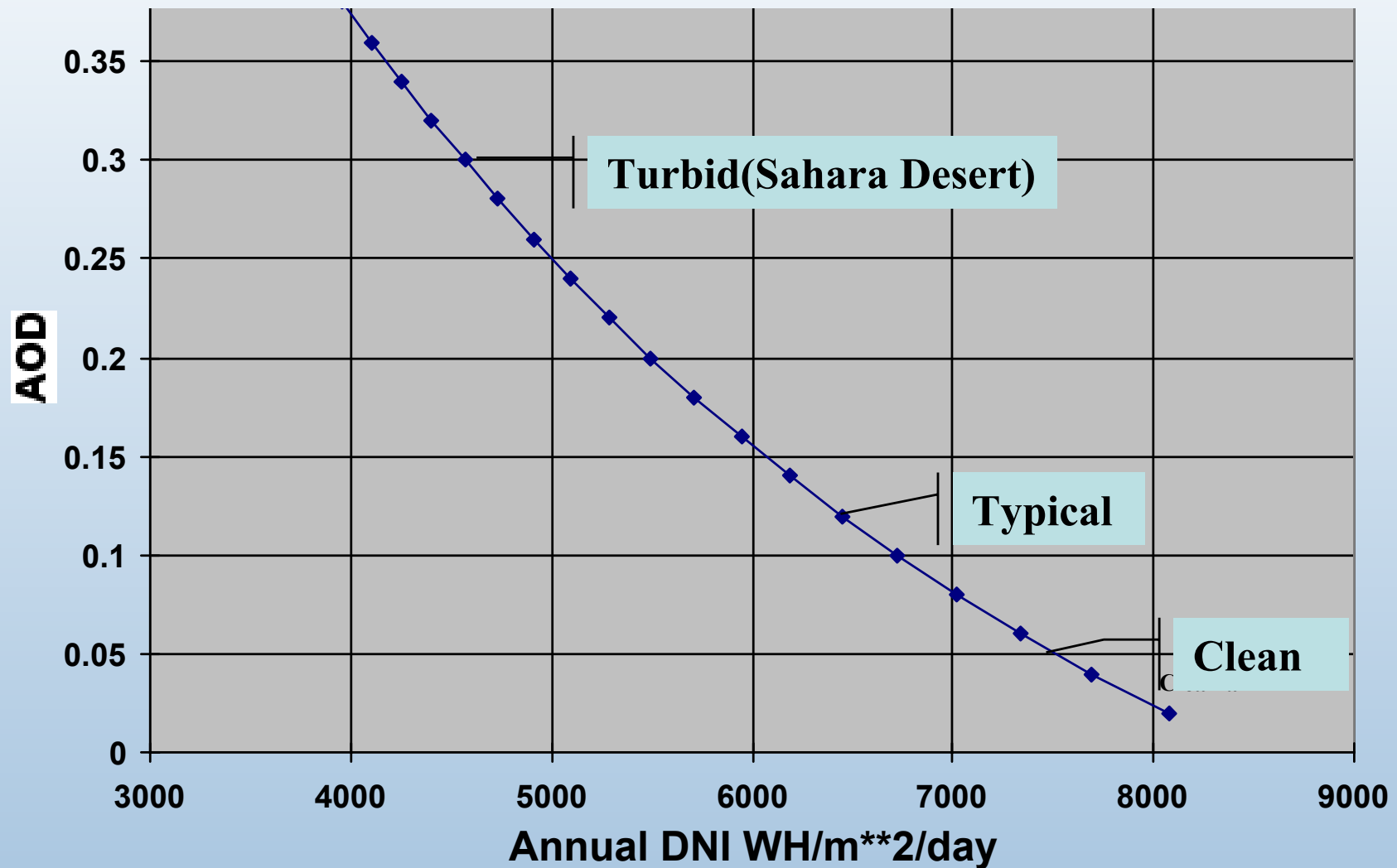


# **Example Analysis Project:**

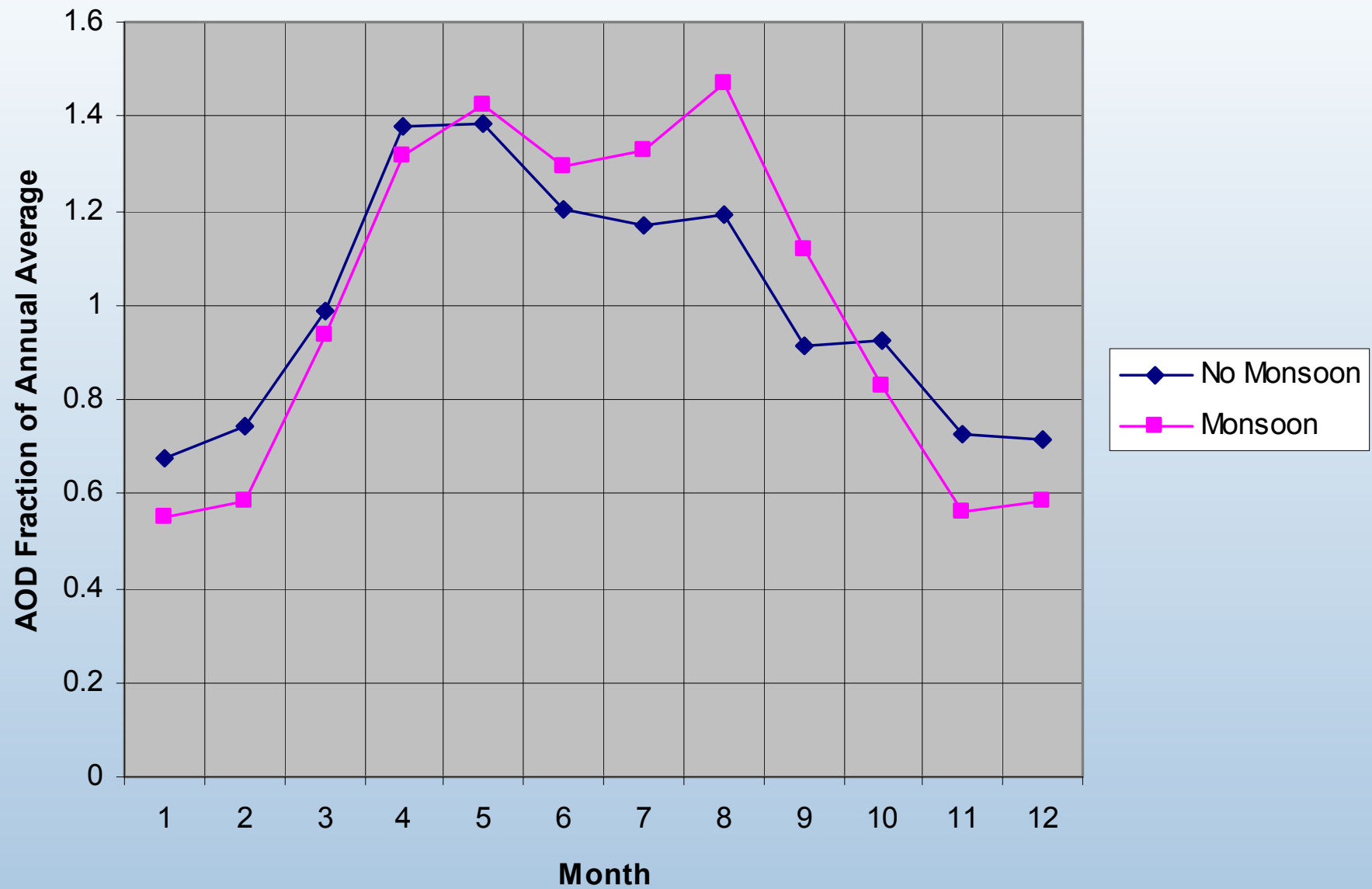
## **Southwest Aerosol Optical Depth**

- AOD - critical input for CSP solar modeling
- Previous study for 1996 solar maps:
  - ✓ Used surface DNI measurements, plus other data inputs to “back out” AOD.
  - ✓ Did not adjust for elevation
  - ✓ Used a simplified seasonal pattern
- For new aerosol data, we wanted to:
  - ✓ Use new high quality surface AOD measurements
  - ✓ Use more realistic seasonal patterns over deserts
  - ✓ Adjust AOD for elevation.

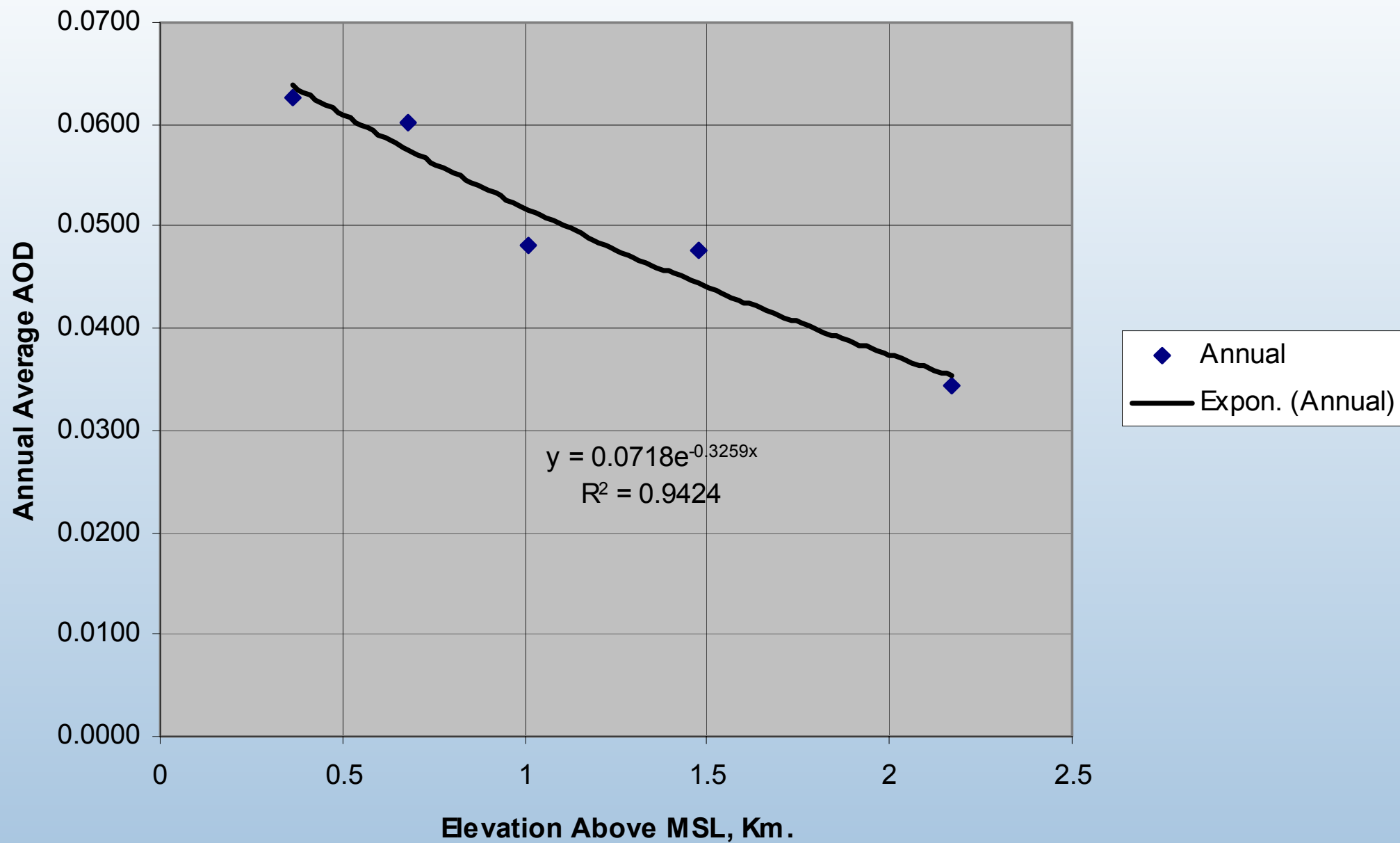
# DNI Very Sensitive to Aerosol Optical Depth (AOD)



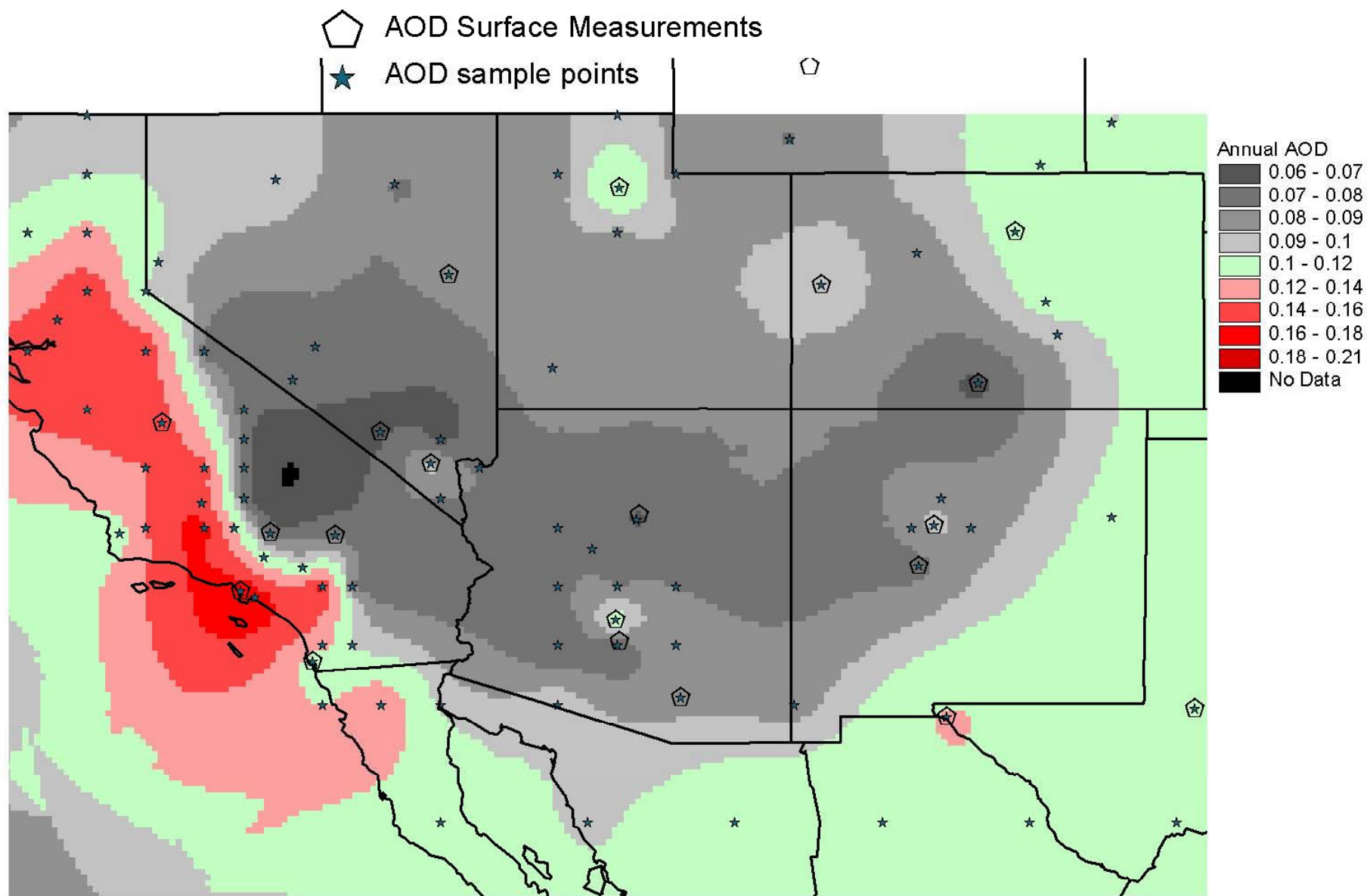
## Southwestern Seasonal Aerosol Patterns



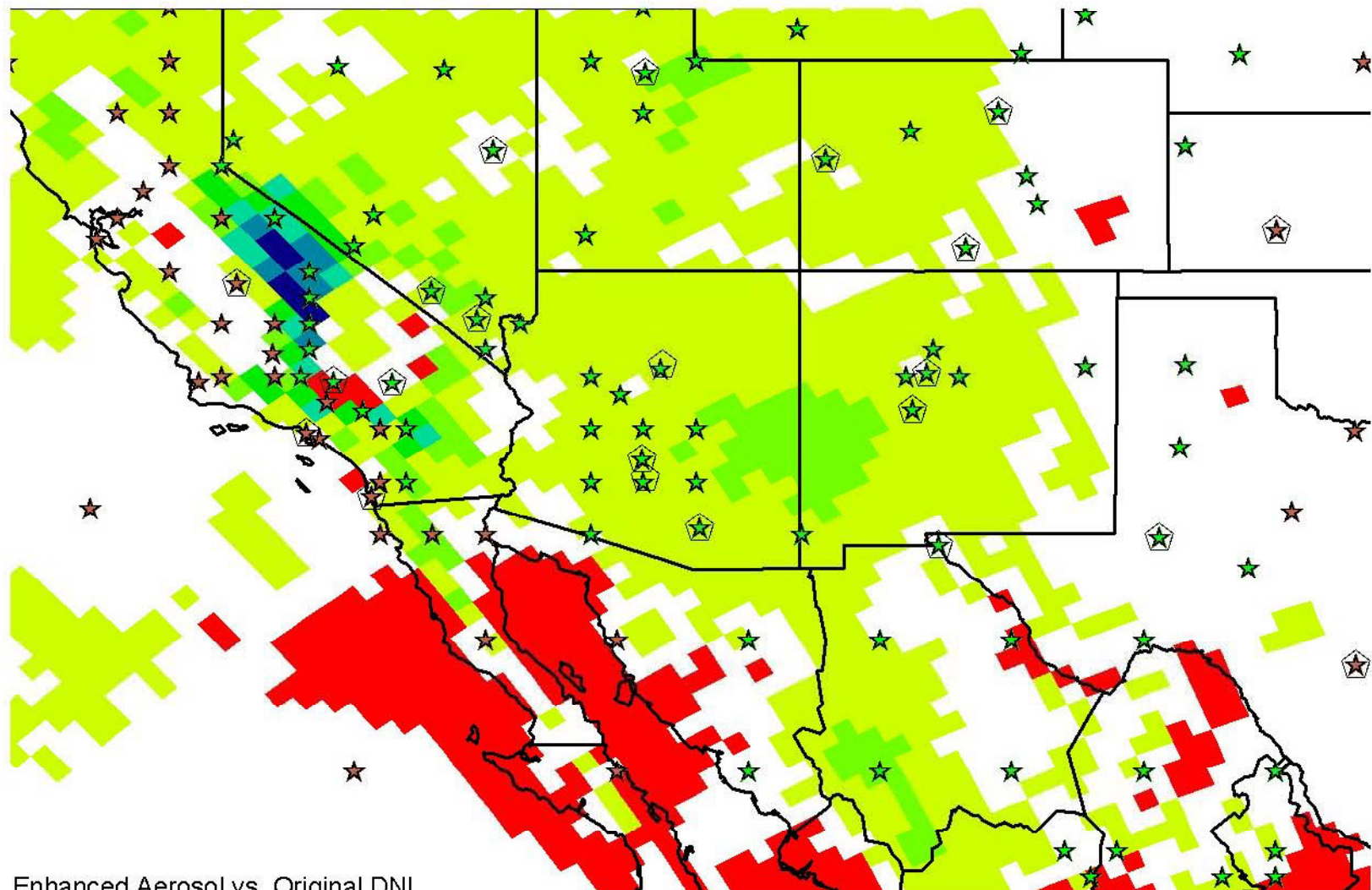
## Annual AOD vs Elevation



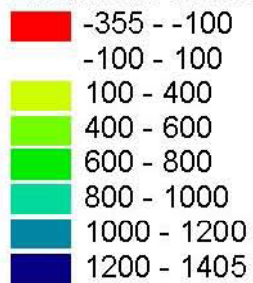
# Annual AOD Adjusted to Sea Level



## Annual Average DNI - Change with Enhanced Aerosols



Enhanced Aerosol vs. Original DNI



○ AOD from Surface Observations  
SW aerosol profiles  
★ Maxwell Profiles  
★ SW profiles

# Possible Enhancements to Reduce AOD and Hence DNI Uncertainty?

- Evaluate uncertainty of AOD estimates using surface data locations, terrain complexity, other data, statistical methods?
- Evaluate reduction in uncertainty if we get new data from a hypothetical location.
- Process many proposed locations to choose optimum location for new surface measurements.





# Potential Data Sets For Regionalization To Support National Level Models

## Renewable Energy Resources

- Wind resources, long-term regional multipliers
- Wind Supply/Demand, Capacity factors by time of day/season
- Biomass supply
- Geothermal resources
- Solar insolation for distributed PV & CSP systems
- PV & CSP capacity factors by time of day/season
- Hydro resource or supply curves for new sites
- Hydroelectric Conventional Net Summer Capacity
- Landfill Gas Yield Ratios

# Potential Data Sets For Regionalization To Support National Level Models (cont)

## Electricity

- T&D interconnection costs
- Extra T&D costs for wind
- T&D costs avoided by DG
- Electricity Demand
- Retail Sales of Electricity
- Average Retail Price of Electricity
- Electric generation plants
- Electric transmission lines
- Electric transmission line rating and available capacity
- Emissions by power plant
- Natural gas pipeline location and capacity
- Coal reserves
- Current coal capacity
- Coal consumption
- Current natural gas capacity
- Natural gas reserves
- Natural gas consumption
- Hydro capacity (river and flow rates?)

# Potential Data Sets For Regionalization To Support National Level Models (cont)

## Residential and Commercial

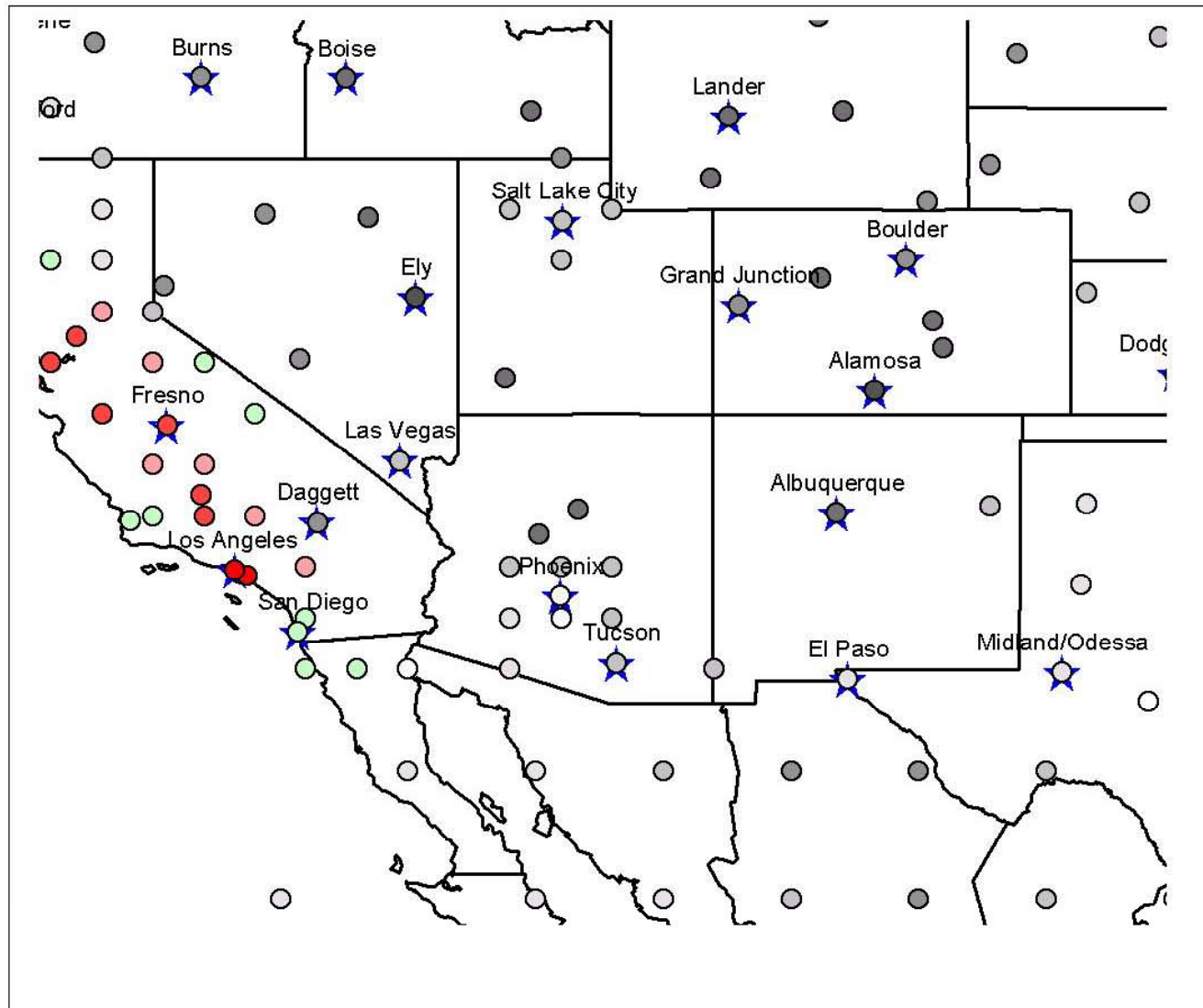
- Heating Degree Days and Cooling Degree Days
- Appliance shares (number of homes with freezers, DW, CW, CAC, Room AC)
- Pipeline capacity for gas-fired DG
- Renewable energy incentives
- EPA designated non-attainment areas
- Clean Cities
- Major commercial/industrial users of electricity; demand, supply
- Population
- Household characteristics
- Energy consumption by source and end use sector
- Residential electric demand
- Military electric demand, supply

# BACKUP SLIDES

# Procedure For Updated AOD

- Process surface AOD from 6 stations (high quality, limited spatial extent)
- Use average monthly profiles for interior location in the Southwest. Assign profiles to every model grid cell with the help of outside (cloud) data.
- Derive elevation dependence of AOD
- Adjust annual mean values to sea level
- Resample to 10 km grid
- Adjust final aerosol values using 10 km elevation data.

# Aerosol Station Values, 1996 CSR Data Grid



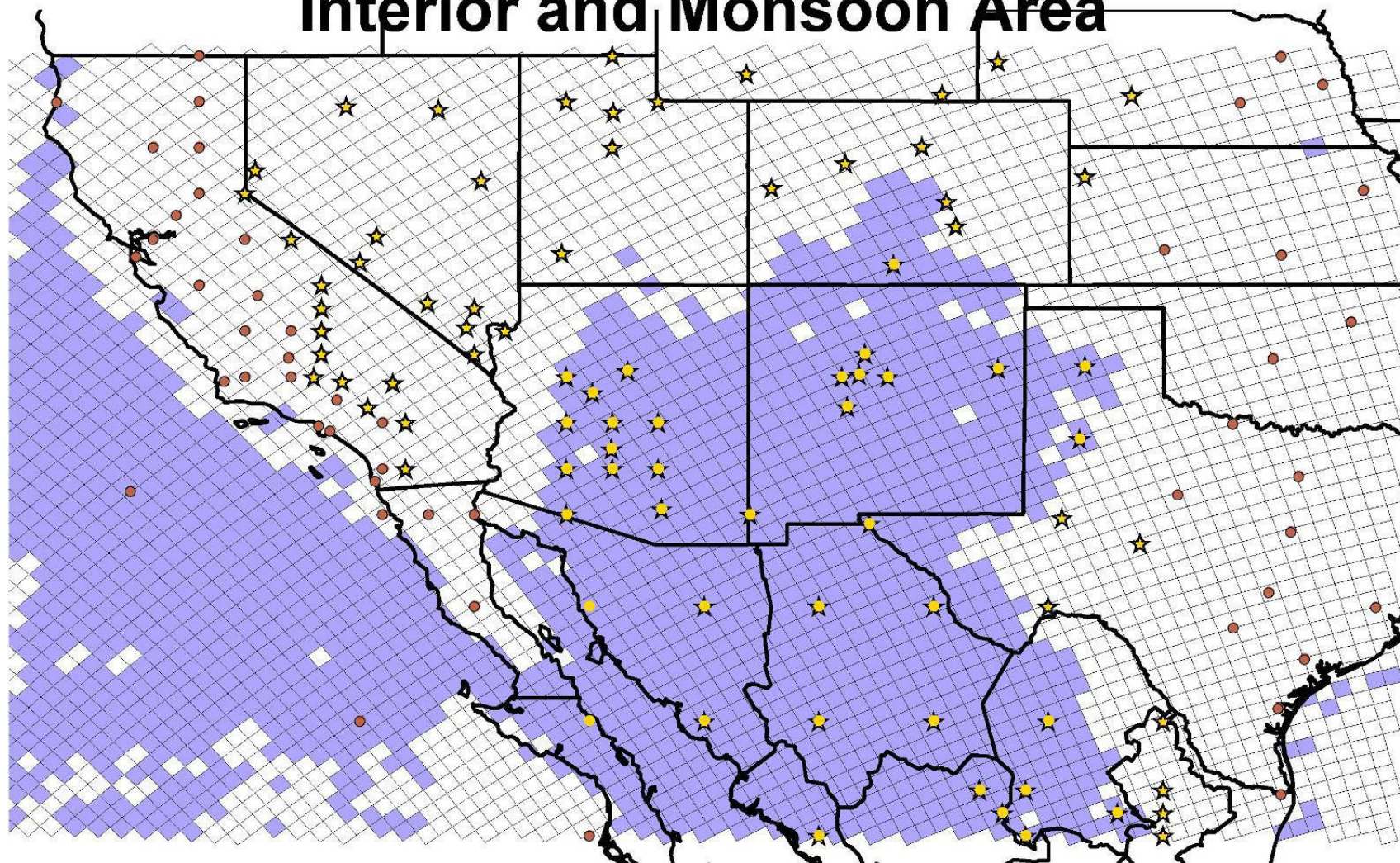
★ Data Grid DNI Stations

## Annual BAOD

- 0.032 - 0.05
- 0.05 - 0.06
- 0.06 - 0.07
- 0.07 - 0.08
- 0.08 - 0.09
- 0.09 - 0.1
- 0.1 - 0.12
- 0.12 - 0.14
- 0.14 - 0.16
- 0.16 - 0.18
- 0.18 - 0.3



# Choosing Aerosol Profiles in Southwest Interior and Monsoon Area



**Monsoon Point**

○ 0  
● 1

**Southwest Point**

● 0  
★ 1

**August Cloud Max**

□ 0  
■ 1



# Adjusting Aerosol Profiles in Southwest Using Elevation

